HY™-BWMS-200 Ship Ballast Water Management Systems

Plan of Ship-based Test Project

Test Unit: The First Institute of Oceanography, SOA

Verification Unit: China Classification Society

Research Unit: Shanghai Hengyuan Marine Equipment Co., Ltd.

Ship for Test: Passenger Cargo Ship No. Magnolia Liliiflora under China Shipping International Ship Management Co., Ltd.

November 2012

Catalog

1. Description and Purpose of the Project

Shanghai Hengyuan Marine Equipment Co. Ltd., has put in practice its ISO9001:2000 quality control system, and it has exercised efficacious quality control over the project in line with its spirit of enterprise, i.e. "Take customer satisfaction as the center, and follow after innovation and continuous improvement".

In order to conduct the ship-based test on the ballast water management HY^{TM}-BWMS system developed by the Company as per IMO MEPC.174 (58) resolution given in *Guide Rule for Approval of Ballast Water Management System* (*G8)* (hereafter referred to as G8), we carries out planning conscientiously and carefully, and we communicates and discuss with The First Institute of Oceanography, SOA, and work out this *Quality Assurance Project Plan*. For this test, we may allocate adequate technological resources, ensure qualified brainpower and efficacious instrument, equipment, standards and specifications may exactly reach the site in time, enhance and strictly carry out process control, put in practice rigorous internal quality auditing, supervision and inspection, keep an open mind to accept multiform Surveillance Inspection and verification to be conducted by the authorities concerned and relevant organizations, and adequately assure the authenticity of outcome quality, test processes, sample data and testing results of the project.

The ship-based test covers biological effectiveness, and the test condition and result shall conform to or exceed the requirements specified in G8. The testing items include halonereid, escherichia coli, enterococcus, vibrio cholerae and heterotrophic bacteria.

For implementation of the project, Zhao Bo (general manager of Shanghai Hengyuan Marine Equipment Co., Ltd. and the principal of ballast water project department) serves as the group leader of quality assurance group, and he may be broadly undertake the quality management and control of the project, and guarantee that the project quality may fulfill the requirements given in G8 in accordance with the standard quality system established as per GB/ T19001-2000.

Shanghai Hengyuan Marine Equipment Co., Ltd.

Chairman: Li Shaolin

November 2012

2. Project Implementation Unit and Participants

For the ballast water management system (HY^{TM}-BWMS) developed on the base of filtration + rentschlerizing by Shanghai Hengyuan Marine Equipment Co., Ltd., an application for type approval is filed to the authorities concerned in China, and a ship-based test is conducted as per the requirements of G8.

The First Institute of Oceanography, SOA undertakes the biological activity testing of the project, and it will finish the entire test procedure strictly as per the *Quality Control Plan* and *Quality Assurance Project Plan* specially established for this project in order to ensure the authenticity and accuracy of test process and test results.

Organizations participating in this project includes:

1. The First Institute of Oceanography, SOA: Undertake the test task of the project, and provide the test result and analysis reports.
2. Shanghai Hengyuan Marine Equipment Co., Ltd.: Undertake the research and study of the products and the prepare for the construction of the ship-based testing platform, and provide all requisite conditions for completion the test project;
3. China Shipping International Ship Management Co., Ltd.: to provide the passenger cargo ship No. magnolia liliiflora which will be modified by Hudong Shipbuilding (Group) Co., Ltd.;
4. Marine Material Science and Engineering Institute of Shanghai Maritime University: undertake working out the testing program, and undertake the site organization and allocation of the project.

All testing processes shall be conducted in the presence of China maritime authorities or ship surveyor appointed by it from China Classification Society.

This ship-based test is finished jointly by personnel from 4 units, and the composition of personnel is given below:

As the research, development and production unit, Shanghai Hengyuan Marine Equipment Co. Ltd., dispatches 5 employees to participate in the test, and they main undertake the rear supply and guarantee including manipulation and operation of in-situ test equipment, electric power, installation and purging.

In addition to providing the ship to be used in on-board test, being responsible for on-site logistics supply support during test and the dispatching work such as ship balance in the course of the ship ballast/discharge, China Shipping International Ship Management Co., Ltd. also assists in the installation on board and the logistics supply support required for the test process such as electricity, safety, the ship balance and shipping space stowage during the ship ballast and unloading etc..

Shanghai Maritime University mainly undertake working out the test program, control the test progress/flow, and assist the testing unit to take samples in process of the test.

The First Institute of Oceanography, SOA undertakes the testing task of the test, and undertakes the on-site sampling and analysis of sample parameters.

Shanghai Hengyuan Marine Equipment Co., Ltd.

Project director: Xia Liang

No.	Name	Educational background	Specialty	Job title	Responsibility for the project
1	Zou Maoxia	Undergraduate	Fluid engineering	Deputy general manager	Project director
2	Xia Liang	Undergraduate	Electrical engineering	Engineer	Autocontrol
3	Wu Bin	Undergraduate	Mechanical engineering	Engineer	Mechanical design
4	Li Guixin	Undergraduate	Mechanical engineering	Engineer	Mechanical design
5	Wang Yonghua	College graduate	Quality manager	Engineer	Quality manager
6	Ma Quansheng	College graduate	Mechanical engineering	Engineer	Quality manager

The First Institute of Oceanography, SOA

Project director: Li Ruixiang (researcher).

No.	Name	Age	Educational background	Specialty	Post/Job title	Responsibility for the project
1	Li Ruixiang	56	Undergraduate	Marine organism	Researcher	Group leader
2	Li Yan	33	Master	Marine organism	Research assistant	Phytoplankton
3	Sun Ping	29	Master	Marine organism	Research assistant	Phytoplankton
4	Zhang Jinxing	56	Undergraduate	Marine organism	Researcher	Microorganism
5	Wang Baodong	46	PhD graduate	Marine chemistry	Researcher	Chemistry
6	Xie Linping	29	Master	Marine chemistry	Research assistant	Chemistry
7	Qu Lingyun	35	PhD graduate	Marine organism	Associate research fellow	Microorganism
8	Liu Ping	29	Undergraduate	Marine organism	Research apprentice	Zooplankton

China Shipping International Ship Management Co., Ltd.

No.	Name	Post/Job title
1	Luo Minyi	Captain
2	Fang Chen	Political commissar
3	Cheng Dongling	Chief mate
4	Liu Ning	Second mate
5	Fan Jun	Third mate
6	Zhang Jun	Chief engineer

7	Shen Qi	Second engineer
8	Shen Weijie	Third engineer
9	Xu Xiaoyong	Fourth engineer
10	Xu Wen	Electrical engineer

Shanghai Maritime University

Project director: Yin Yansheng (professor)

No.	Name	Age	Educational background	Specialty	Post/Job title	Responsibility for the project	Certificate for qualification
1	Yin Yansheng	56	PhD graduate	Marine materials	Researcher	Group leader	See the quality assurance program
2	Dong Lihua	47	PhD graduate	Marine materials	Researcher	Deputy group leader	See the quality assurance program
3	Zhang Li	37	PhD graduate	Environmental material	Researcher	Chemistry	See the quality assurance program
4	Zhou Yun	29	Master	Marine chemistry	Researcher	Chemistry	See the quality assurance program
5	Liu Tao	30	PhD graduate	Marine chemistry	Researcher	Microorganism	See the quality assurance program
6	Guo Na	28	Master	Marine organism	Researcher	Plankton	See the quality assurance program
7	Wang Dongsheng	29	Master	Electromechanical	Engineer	Systems operation	See the quality assurance program
8	Fan Chunhua	36	Master	Electromechanical	Engineer	Systems operation	See the quality assurance program
9	Dong Yaohua	28	PhD graduate	Electromechanical	Engineer	Systems operation	See the quality assurance program

3. Description of the independent laboratory and all test facilities and subcontractors

Qualification of the testing organization and testing method for the project

See *QAPP of HY-BWMS* and *IP and QC of HY-BWMS*

4. Brief Introduction to the Hengyuan Ballast Water Management System

4.1 Introduction to the Hengyuan ballast water management system (HY^{TM}-BWMS)

As per the guide rule G8 (Guide to approval of ballast water management system) and guide rule G9 (approval procedure for ballast water managerial system using active substances) given in the international convention on ballast water management, Shanghai Hengyuan Marine Equipment Co.,Ltd. applies for type approval for "Hengyuan ballast water management systems (HY^{TM}-BWMS) " manufactured by it. All contents given in this report conform to the GESAMP-BWWG information collection and working methods.

Shanghai Hengyuan Marine Equipment Co. Ltd., has developed a set of ballast water treatment system (HY^{TM}-BWMS) based on medium-pressure ultraviolet radiation (MPUV) sterilization technology, which features its building block design and may be nimbly configured as per the requirements for ballast water treatment capacity of ship tonnage. The system is working as per two-stage processing techniques; in other words, ballast water may be subjected to filtration treatment once at the water inlet, and may be subjected to ultraviolet treatment once more before it flows out of the water outlet. In this way, the system may eliminate the possibility to discharge any organism that may revive or revegetate from the ballast compartment into the ocean.

Hengyuan ballast water management systems (HY^{TM}-BWMS) is mainly composed of 3 core units, namely filtration unit, ultraviolet radiation reactor unit and autocontrol unit. Of which, the filtration unit is located before the reactor unit and is used to remove inclusions such as particles from the seawater, and remove part of the marine phytoplankton, zooplankton and microorganism etc. The filtering system is provided with self-purging function, and its operation and purging may not affect the entire treating processes of ballast water, and the post-filtration total dirt retained may be directly discharged into the ballast-gathering sea area such that the total dirt retained may not be carried over to a next destination of voyage.

4.2 Description of ballast water management system HY^{TM}-BWMS

4.2.1 Operating principle of the system

The HY^{TM}-BWMS system adopts a processing method composed of prefiltering ＋ medium-pressure ultraviolet treatment microorganism, its specific operational process is conducted by a control system, and a block diagram of operating principle of the system is given in Fig. 4.1:

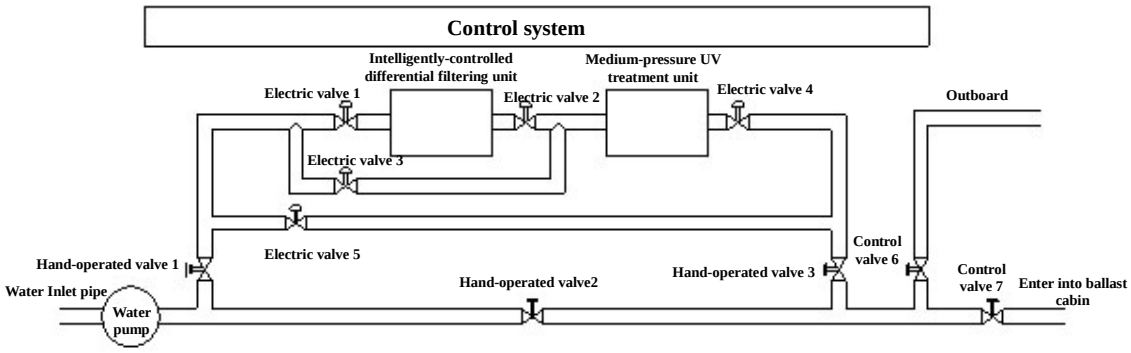


Fig. 1.1 Operating Principle of HY^{TM}-BWMS System

When ballast water is load, the seawater passes through a self-purging filter and ultraviolet treatment unit. The back flushing filth may be discharged in-situ into the seawater ballasting area, such that the other sea area may not be subjected to adventive invasion and contamination. The filtered ballast water is subjected to ultraviolet treatment to kill the microorganism. When ballast water is unloaded, the water inside the ballast compartment is not directed to pass through the filter because it had been filtered when ballasting; however, it may be optionally subjected to ultraviolet treatment so as to prevent the microorganism inside the inside-compartment ballast water from reviving.

The ballast seawater pretreatment conducted by filtration unit may not only prevent bigger organic substances or organism from being carried into the ballast compartment along with the ballast water, but also considerably reduce the content of particles in the filtered and pretreated ballast water, so as to correspondingly reduce the deposited matter inside the ballast compartment and greatly suppress the stemming of microorganism inside the ballast-compartment deposited matter in process of voyage of the ship.

When the filtered ballast water passes through the ultraviolet treatment unit, C-band ultraviolet beats down on the liquid and destroy the DNA and RNA inside the cell tissue of microorganism like bacteria and virus in a flash. The virus or bacteria exposed to that wave band may take in a dose of 6000 ~10000U.W. sec/cm^2 or more, the DNA (deoxyribonucleic acid) inside their vital center goes to rack and ruin such that they die or lose reproductive capacity immediately. Ultraviolet rays fall within broad-spectrum sterilization technology, and it may kill almost any microorganisms, including bacteria, tubercle bacillus, virus, gonite, fungi and algae etc.

With the aid of treatment conducted by ballast water system HY^{TM}-BWMS, the discharged ballast water may meet the standard specified in the IMO resolution for ballast water. The major components and performance of HY^{TM}-BWMS ballast water system are given as follows:

System composition: auto intelligent-control pressure-difference filtration unit, medium-pressure ultraviolet treatment unit, solenoid valve and connecting line, control system and several testing sensing probes

Treatment capacity: 150~ 1600m^3/h, optional

Supply voltage: AC380, 3-phase

Filtration fineness: 40μm

UV dosage: 200 mJ/cm^2-300mJ/cm^2

Design pressure: 16kg/cm^2

Operating pressure: 1.5~10kg/cm^2

4.2.2 Product specification of ballast pumping system HY^{TM}-BWMS

With its modularized packaged design, HY^{TM}-BWMS is applicable to treatment of ballast water with a flow rate ranging from 150m^3/h to 3000m^3/h. The fail safe system allows flexible configuration, and is highly suitable to install and work on built or newly-built ships. The product specification and series of HY^{TM} –BWMS ballast pumping system are listed in Table 4.1:

Table 4.1 Performance Parameters of Basic Units of Ship's Ballast Water Treating Plant HY^{TM}-BWMS-200

Parameters of basic units of HY^{TM}-BWMS -200	
Model	**HY^{TM}-BWMS- 200**
Rated treatment capacity (m^3/hr)	**200 m^3/h**
Power range/ average (KW)	**18-26/20KW**
Inlet-outlet pressure difference (MPa)	**0.05MPa**
Pressure-proof pressure (MPa)	**1.0MPa**
Filtration fineness (um)	**40um**
Overall size (m)	**2.58X1.05X2.23 (2.7)**
Weight (Kg)	**1750**

Based on the specs and models of above-mentioned major components (including intelligent control pressure difference filtration unit and ultraviolet treatment unit), HY^{TM}-BWMS ballast water management system may allow different combination of its major component to meet the clients' requirements for ballast pumping system. The specific product serials are listed in Table 4.2.

Table 4.2 Product serials of HY^{TM}-BWMS Ballast Water Management System

Product serial Number	Treatment Capacity m^3/hr	Power (KW)	Overall size (m) (LXWXH) and area (m^2)	Weight (kg)	Remarks
HY^{TM}-BWMS- 150	150	12-18/14KW	2.58X1.05X2.23 (2.7)	1750	Basic unit (substitute)
HY^{TM}-BWMS- 200	200	18-26/20KW	2.58X1.05X2.23 (2.7)	1750	Basic unit
HY^{TM}-BWMS-400	400	36-48/42KW	2.6X1.05X2.71 (2.73)	2100	Two sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-600	600	60-72/62KW	2.6X1.05X2.71 (7.23)	2100	Three sets of **basic unit combination of HY^{TM}-BWMS- 200**

HY^{TM}-BWMS-800	800	72-96/74KW	2.6X2.78X2.71 (7.23)	3400	Four sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1000	1000	96-120/96KW	2.6X2.78X2.71 (7.23)	3400	Five sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1200	1200	96-120/102KW	2.6X2.78X2.71 (7.23)	3400	Six sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1400	1400	126-168/132KW	2.8X4.4X2.71 (12.32)	4800	Seven sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1600	1600	144-192/150KW	2.8X4.4X2.71 (12.32)	4800	Eight sets of **basic unit combination of HY^{TM}-BWMS- 200**

Fig. 4.2 shows a photo of Integrative construction of treatment device intended for ship-based test of HY^{TM}-BWMS, of which the treatment capacity is 200m^3/h

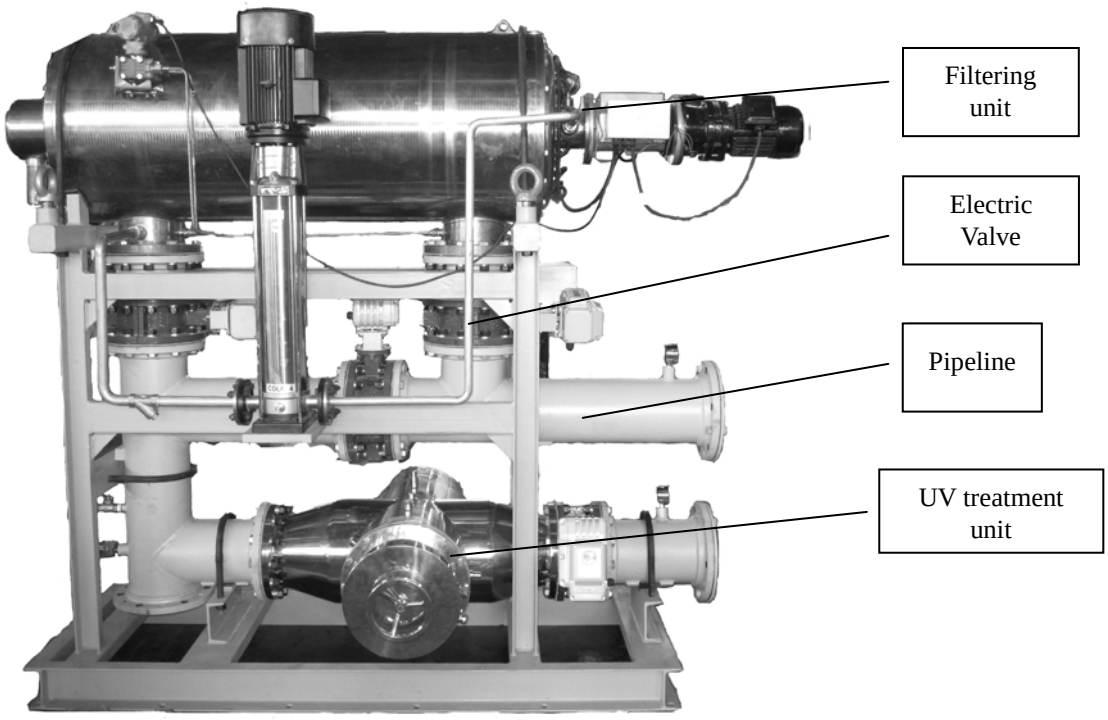


Fig. 4.2 General Assembly Drawing of HY^{TM}-BWMS-200 Ballast Water Management System

The working flow of the system is shown in Fig. 4.3a and Fig. 4.3b.

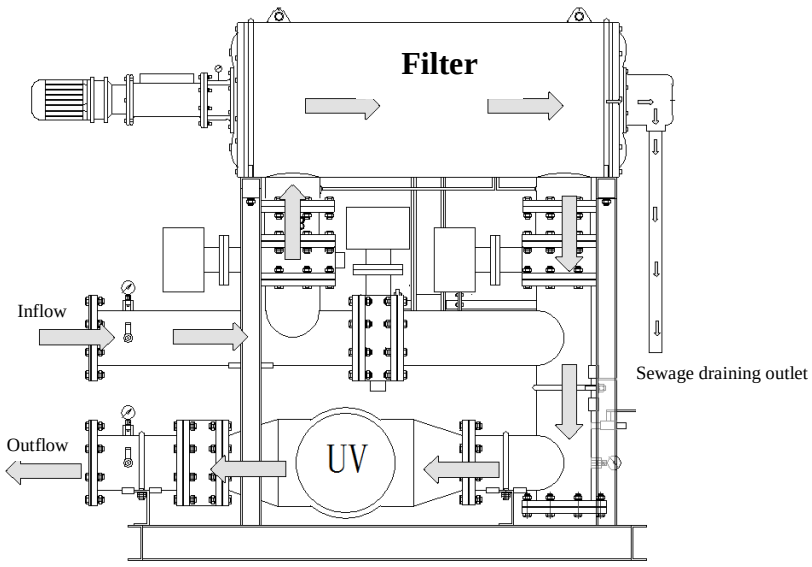


Fig. 4.3a Flow Chart of Ballasting of HY^{TM}-BWMS-200 System

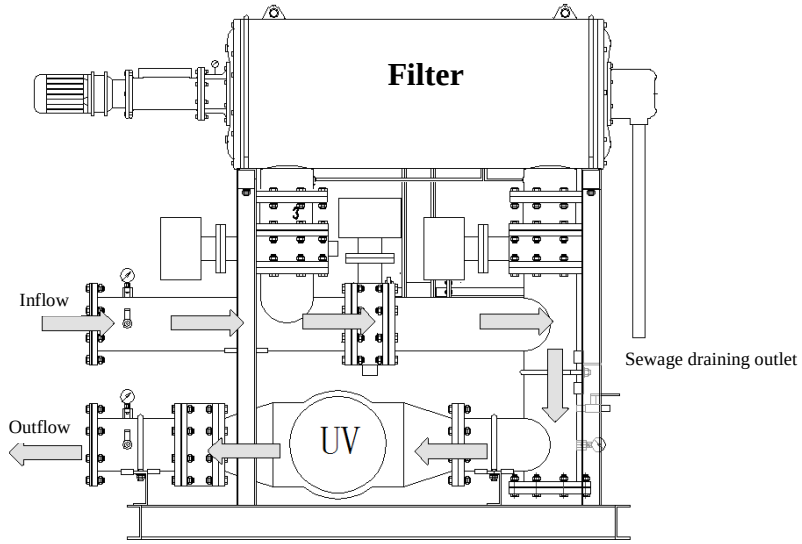


Fig. 4.3b Flow Chart of Unloading of HY^{TM}-BWMS-200 System

4.2.3 HY^{TM}-BWMS-200 Intelligent-control pressure-difference filtration unit

HY^{TM}-BWMS ballast pumping system is equipped with an intelligent-control pressure-difference filtration unit furnished with high-strength screen mesh and filtering element, and the perfect filtration and pretreatment functions are capable of high-pressure backwash, automatic blowing down, full automatic manipulation of operational process, and blowing down without setting-off.

In contrast with other similar filtering equipment, the intelligent-control pressure-difference filtration unit is provided with the following characteristics:

- The intelligent-control pressure-difference filtration unit is equipped with a 40-micron high-strength sintered

mesh. It may carry out backwash up to a high pressure of 2.0Mpa to thoroughly clean the strainer mesh at high efficiency to fully recover it to its initial state so as to achieve lifetime service without replacement.

- The filter separator is capable of automatic indexing, automated implementation of high pressure back flushing as per the various retrieved data, and unattended operation regardless of unstable fluctuation of water quality without manual intervention.
- The control system features rapid response and accurate operation, and it may regulate the backwash pressure-difference as per different water sources;
- Capable of back flushing without interruption of normal water producing, ensuring continuous, steady and reliable operation.
- Short duration of back flushing, such that the backwash water consumption is restricted to only 0.001 ~ 0.002% of normal water yield, ensuring water conservation, power conservation and energy conservation.
- Compact and reasonable structural design, with less wearing parts, without consumables, with low operation and maintenance costs, ensuring easy operation, management, installation and relocation.

Its contour and internal structure are shown in Fig. 4.4

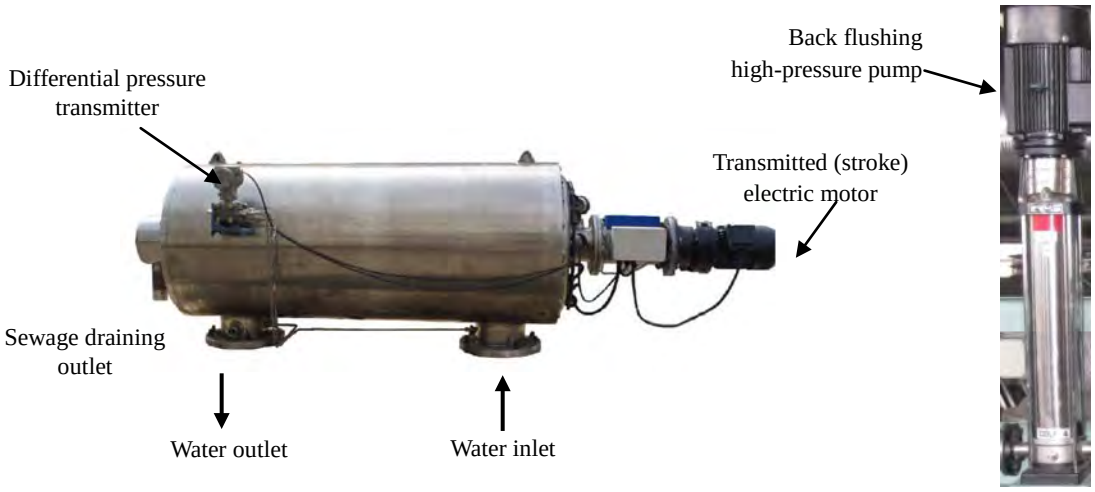


Fig. 4.4 Major Component of Automatic Intelligent-control Pressure-difference Filtration Unit

Specific technical parameters of operation are listed in Tables 4.3 and 4.4:

Table 4.3 Technical Parameters of Operation

Filtration fineness	40um
Unit-set underground-water testing flow-rate (rated)	200m^3/h
Minimum operating pressure	0.15MPa
Maximum operating pressure	1.0MPa
Pressure loss	0.01～0.05MPa
Temperature of filtering medium	0～70℃

Normal output (ultrasonic)	1.44 kw

Technical parameters of purging

Table 1.4 Technical Parameters of Purging

Back flushing pressure	2.0MPa (varying depending on operating pressure)
Duration of back flushing	60 seconds
Water consumption for back flushing	120~160 L (varying depending on operating pressure)
Power consumption for back flushing	0.085kw/time

4.2.4 Ultraviolet (UV-C) treatment unit

The ultraviolet light treatment unit can effectively kill the halonereid, phytoplankton, heterotrophic bacteria, pathogenic bacteria and virus.

The contour of ultraviolet (UV -C) module is shown in Fig. 4.5.

Fig. 4.5 Appearance View of Ultraviolet Treatment Unit

The ultraviolet treatment unit is mainly composed of the following several sections: strip lamp, jacket pipe, amperite, power supply, stainless-steel reaction device, accumulative time demonstrator, ultraviolet intensity monitor and manual purging arrangement. The ultraviolet treatment unit is provided with the following advantages:

- Allowing series or parallel connection as per different treatment capacity required for the application
- Capable of completely killing any residual heterotrophic bacteria and organism after stage-1 and stage-2 filtration.
- Free of toxicity residue

- Highly significant sterilization effect
- Easy maintenance and operation

4.2.5 Control and monitoring device

The control box of ultraviolet treatment unit is shown in Fig. 4.6:

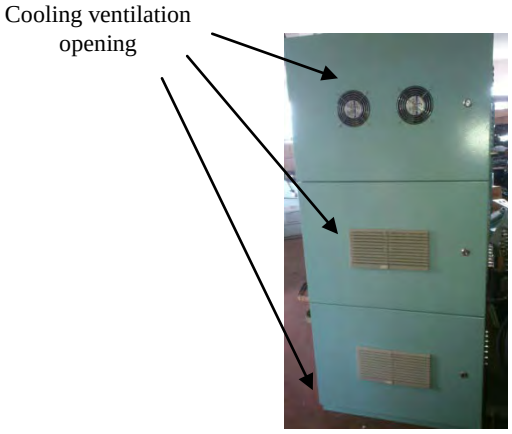


Fig. 4.6 Control Cabinet of Ultraviolet Treatment Unit

The electric control cabinet is cooled by a fan so as to ensure the heat elimination of capacitors and UV -C supply transformer. The section is intended to provide working power supply and control source for the ultraviolet lamp.

The control and monitoring system may monitor the systems operation and feed power supply to the components. HY^{TM}-BWMS is provided with multiple monitoring points used to measure and self-regulate the parameters such as pressure, flow rate, temperature, turbidity and ultraviolet exposure dosage. The data acquired from these measuring points may be transmitted to the control center of the system (Fig. 4.7) for managing and controlling the self-adjusting parameters of supply unit and valves in order to ensure true running of the system.

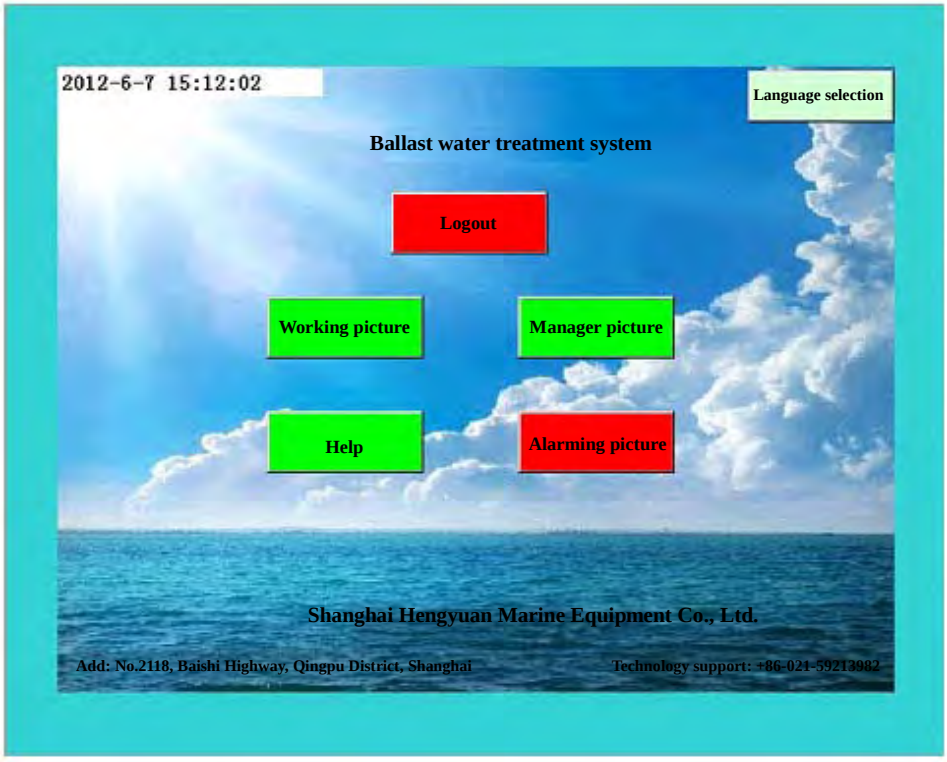


Fig. 4.7 Main Interface of Touch Screen of Control and Monitoring Device

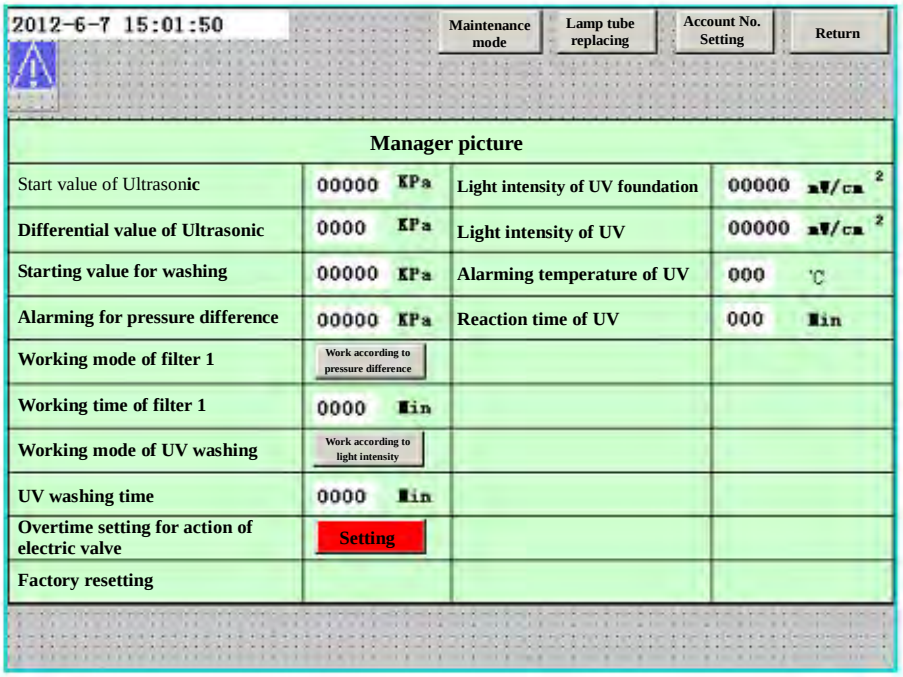


Fig. 4.8 Administrator parameter setting interface

The control device of HY^{TM}-BWMS may automatically and constantly monitor and adjust all parameters required for UV-C module during operation. In case an exception occurs in the working parameters of UV-C, audible and visual alarm information may be output, and the position and fault category of the exception may be indicated. During the ballasting and unloading, the UV module may be automatically regulated as per the signals output by the UV -C intensity sensing probes built in the system, so as to ensure that the efficacious exposure dose must not be exceeded.

5. Design of Ship-based Test Program

5.1 Outline of the ship-based test

There are four tests for the ship-based test. And the test is planned to test the function of the HY^{TM}-BWMS (ballast water treatment system) under the normal working condition. The specification of the ballast water treatment system used in this loading test is 200m^3/h.

When loading the ballast water, firstly, the seawater will flow through the intelligent control pressure difference filter unit by which the large particles microbe will be kept out of the ballast cabin, and then the ballast water will flow through the ultraviolet treatment unit for being treated, finally flow into the ballast cabin. Back flush sewage from the filter and the pretreatment water for the Ultraviolet treatment unit will be drained off locally at the place of loading seawater, without bringing the invasion of non-indigenous organism and pollution to other sea areas.

When unloading the ballast water, because the water in the ballast cabin has been filtered when loading, it will not flow through the filter in this process but still needs to be treated by the ultraviolet, so as to avoid the resurgence of the microbe in the ballast cabin. The water that has been treated will be discharged overboard.

The ship-based test will be conducted on the passenger cargo ship No. magnolia liliiflora which sails between Lianyungang of China and Korea port of Inchon. The characteristic parameters (salinity, temperature, organic carbon granule and total suspended solids) of the source water used by the measurement test during test and the survival condition of the biology in the ballast water samples that have been treated contrastively and not treated shall conform to the requirements of G8 and standard D-2. The sampling process and final determination shall adhere to the guidance concerning the ob-board test in IMO G8.

5.2 The basic information of the ship used in the ship-based Test

- Name of ship: No. magnolia liliiflora
- Type: Passenger cargo ship
- Overall Length: 151 m
- Length between perpendiculars: 137.5
- Designed waterline length: 7.15m
- Molded breadth: 24m
- Rated capacity of the ballast pump: 300m^3/h
- Total capacity of the ballast cabin: 2456m^3/h

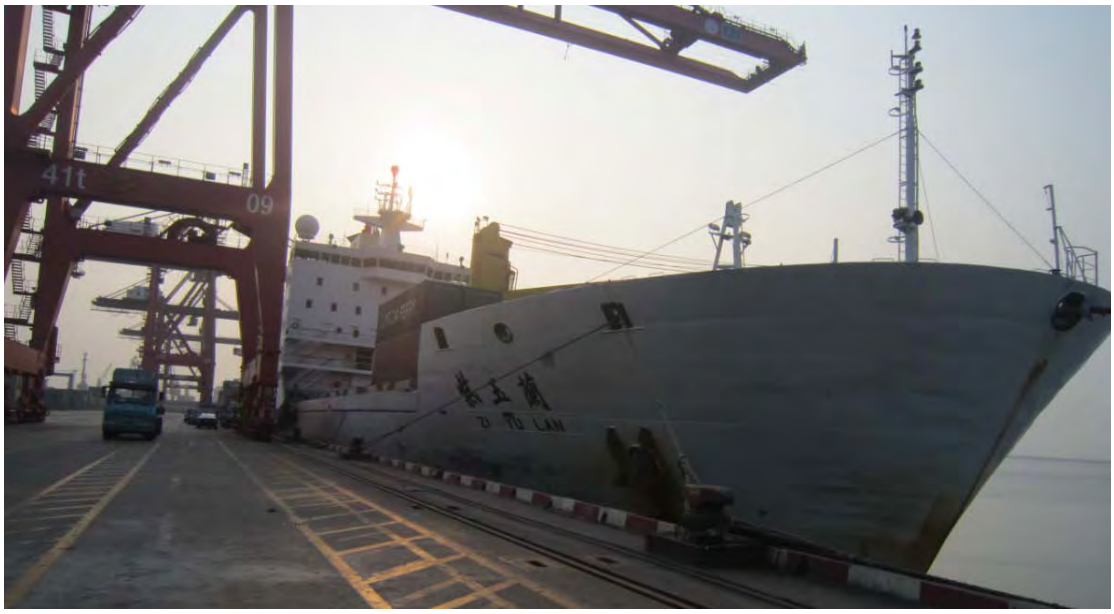


Fig. 6 Photo of the Ship Used for Test

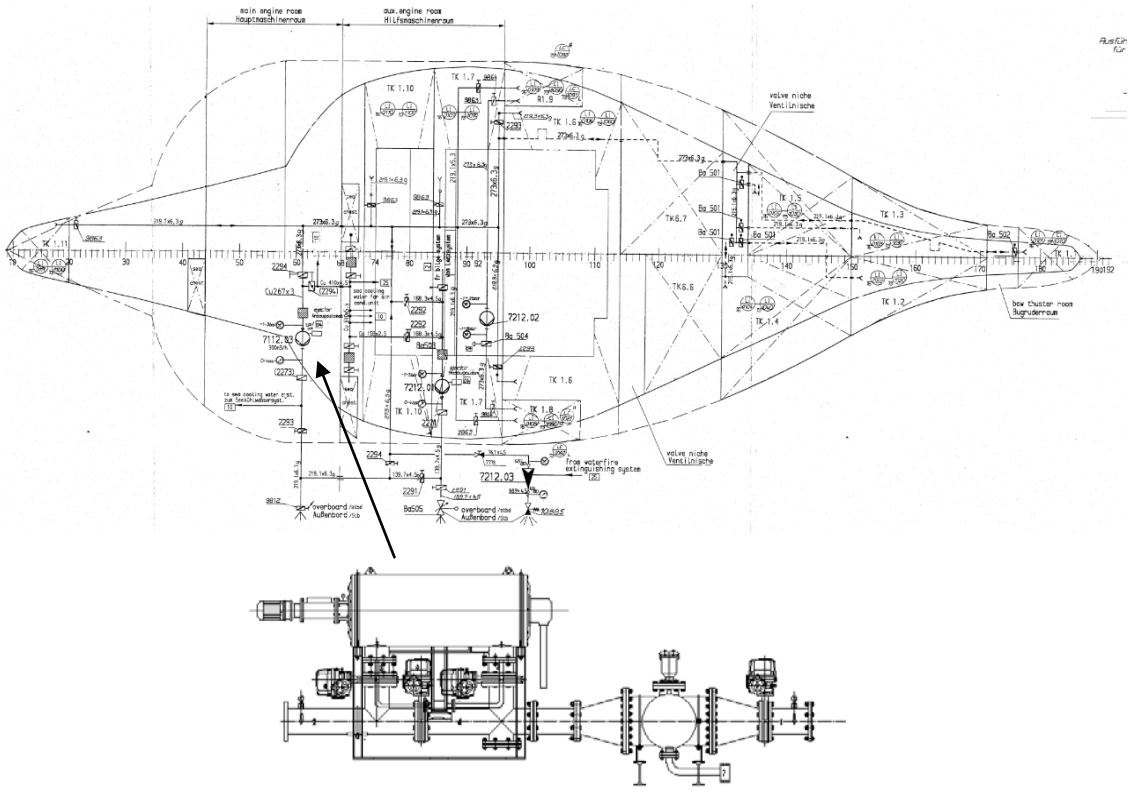


Fig. 7 The location for the HY^{TM}-BWMS to be installed within the ship

The HYT-BWMS should be installed next to the ballast pump in the engine room (Fig.7) of the ship used for test.

The ship No. magnolia liliiflora has total ten ballast cabins. The number and capacity of each ballast cabin are shown as below table:

No.	Capacity (M^3)	Application
1.1	362	Ballast
1.2	348	Ballast
1.3	346	Ballast
1.4	218	Ballast
1.5	203	Ballast
1.6	175	Ballast
1.7	132	Ballast
1.8	Not applicable	Balance bunker
1.9	Not applicable	Balance bunker
1.11	672	Ballast

For the specific location of each ballast cabin, see Fig.8 (the larger image as seen in annex)

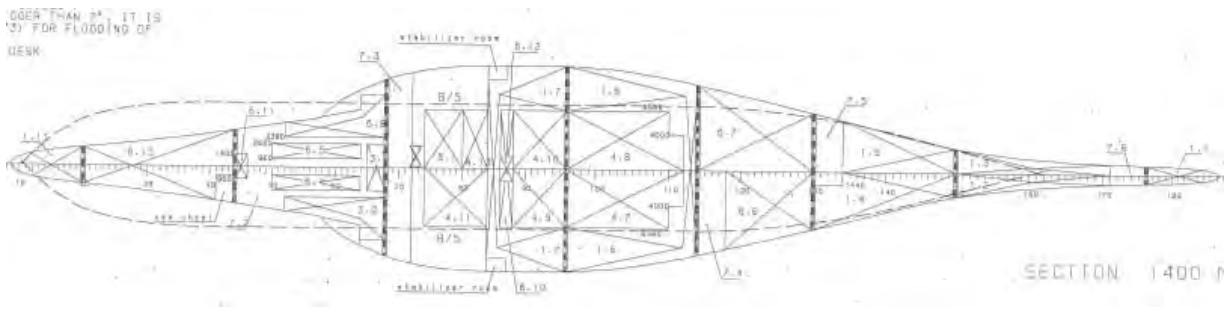


Fig.8 Layout of the Ballast cabins of the Ship No. Magnolia Liliiflora

The ballast cabins used in this ship-based test mainly are those no. 1.1, 1.2, 1.3 and 1.11.Among which, the ballast cabins no. 1.1, 1.2 and 1.3 are located at ship bow (see Fig.9) and the ballast cabin no. 1.11 is located at stern (see Fig.10). The ballast cabin no.1.1 is mainly used for storing the contrast bilge water and the ballast cabins no. 1.2, 1.3 and 1.11 are mainly used for storing the treated water. Since the ballast cabin no. 1.11 is located separately at the stern while others located at ship bow, it can be used for storing the treated water so as to effectively prevent the ship pipelines from cross contamination. The treated water stored in the ballast cabins no. 1.2 and 1.3 is mainly used as standby and also can be used for washing the pipelines before discharge or ballast.

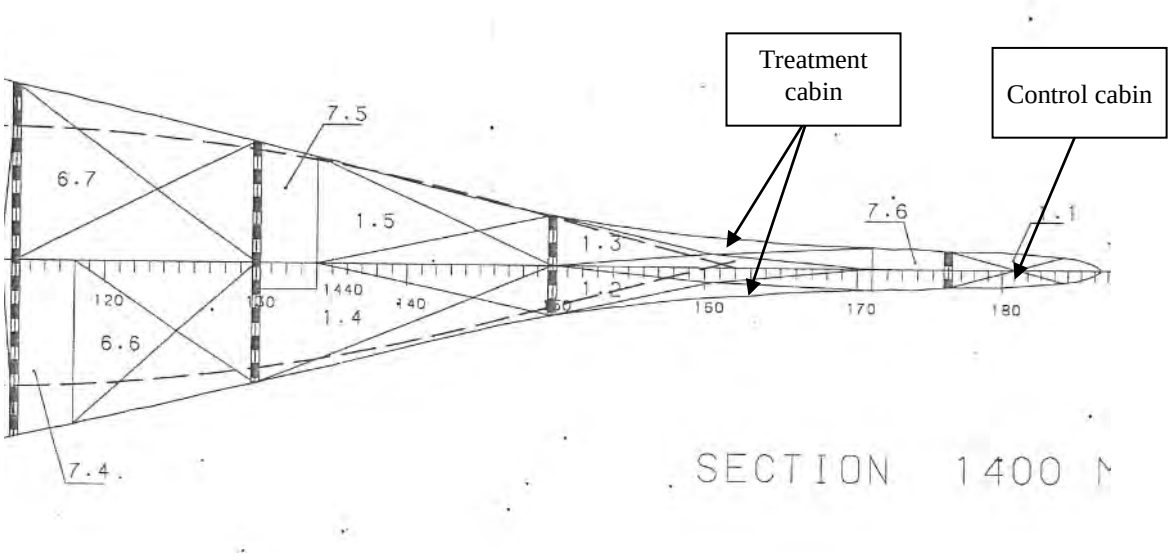


Fig.9 Layout of the Ballast cabins at the Ship Bow

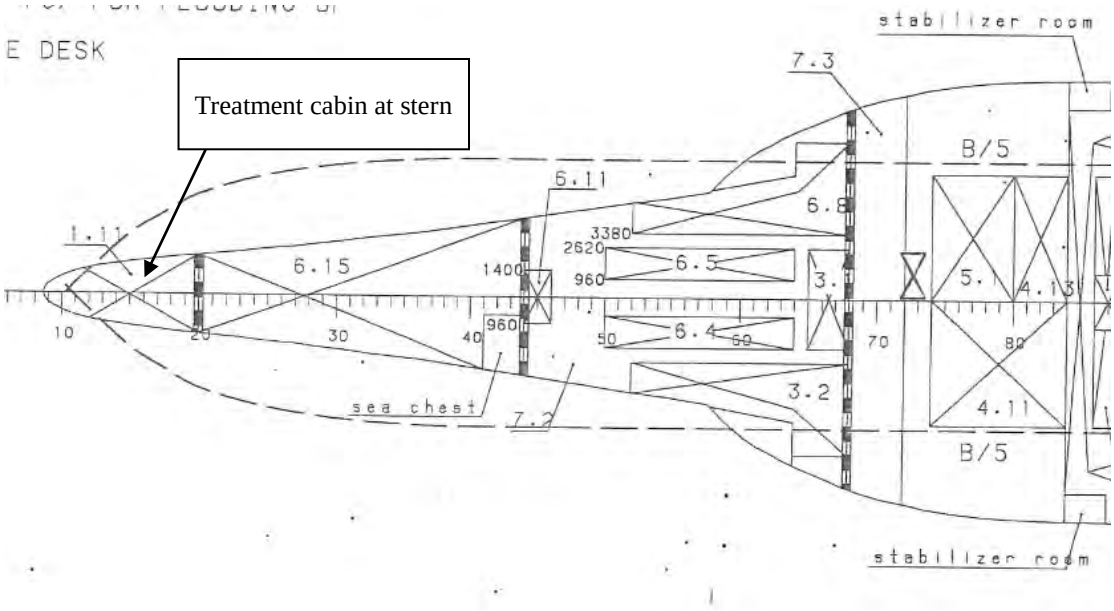


Fig.10 Layout of the Ballast cabins at the Stern

5.3 Test arrangement

When the ship is under ballast operation, firstly it will ballast the ballast water treated by the ballast water treatment systems into the treatment cabin no. 1.2 or 1.3 for washing the ballast pipelines, and then ballast the water into the treatment cabin no. 1.11, finally the ballast water will be ballasted directly into the control cabin no. 1.1 without being treated by the treatment system;

When the ship is under unloading operation, firstly the ballast water treatment system will be used to discharge the treated water in the treatment cabin no. 1.2 or 1.3, and then the ballast water in the treatment cabin no.1.11 will be discharged, finally the control cabin is unloaded.

5.4 Test parameters

HY^{TM}-BWMS ballast water management system may test the following parameters:

(1) Organism: ≥50μm and 10～50μm;

(2) Microorganism: escherichia coli, vibrio cholerae and heterotrophic bacteria;

(3) Water quality: pH value, temperature, salinity, dissolved oxygen, TSS, DOC, POC and NTU

5.5 Treatment capacity of the testing apparatus

Treatment capacity: 200±10 m^3/h

Treatment: for secondary treating during ballast and unloading

The water volume to be treated: more than 330 m^3 for each ballast cabin.

5.6 Commissioning and trial run of the equipment

Before the ship-based test, the original traveling ship will be modified and meanwhile the secondary design will be conducted on the basis of the cabin space and structure of the ship for test. After that the modified ship also cannot be transferred to the engine room until it is assembled, debugged and run on shore.Before testing, in order to confirm that the whole system can run normally and to validate the reliability of the whole HY^{TM}-BWMS ballast water management system and its valves, pumps, pipelines, and meanwhile a drill should be conducted on the manning and the actual operation process such as the sampling method, time and place etc. that is necessary for the test process, a cycle of trial run should be carried out according to the operation process described in the program, to ensure the ship-based test can be normally conducted.

5.7 Preparation prior to the land-based test

According to the guidance of G8, only when the concentration of the active organic matter flowed into the water is 10 times more than the value specified in clause D-2.1, and the concentration of the active organic matter in the water drained from the control cabin is more than the value specified in clause D-2.1, the test is effective. Therefore, before conducting the ship-based test, firstly the sample should be sampled to detect whether the concentration of the active organic matter in the seawater from the ballast sea areas conforms to the requirements, if not, the ballast sea areas or places should be adjusted.

5.8 Test progress arrangement

This ship-based test is planned to officially start on November 18, 2012. The ballast place is in Lianyungang of China. After ballast, only when the ship sails to Korea port of Inchon for a week of voyage and then sails back to Lianyungang, the unloading can be conducted. The ship-based test will be conducted for four times and it should make sure that the three effective cycles will be completed within six months.

Test cycle	Sampling date for ballast	Starting and ending time	Sampling time for unloading	Starting and ending time
1	2012-11-19	6:30-9:30	2012-11-26	6:00-7:30
2	2012-11-26	7:30-10:30	2012-12-3	6:00-7:30
3	2012-12-3	7:30-10:30	2012-12-10	6:00-7:30

4	2013-5-27	6:30-9:30	2013-6-3	6:00-9:30

5.9 Test operation procedure

The test content and number for each day in every test cycle are shown as below table.

Time	No.	Operation of specific operating content
Preparation	1	Inspect whether the equipment for management system of HY^{TM}-BWMS ballast water run stably or not. Stable system operation means that pressure, flow and UV irradiation intensity inside the system pipe have reached to rated value under rated current, voltage and power dissipation, similarly hereinafter.
	2	To detect whether the seawater conforms to the requirements of G8, including detecting TRO, organic matters and chemical and physical properties (POC, DOC, TSS, decomposition of oxygen, PH value, salinity, temperature and turbidity).
	4	Inspect whether sampling equipment are accurate, including PE barrel and filtering screen, etc.
	5	Inspect whether the electric power and pipeline, etc are well prepared.
	6	
Ballast	1	Start on the ballast water treatment test of the first cycle: a part of the inlet water will flow into the ballast cabin after being treated by the HY^{TM}-BWMS, and the other part of inlet water will directly flow into the control cabin without being treated by the HY^{TM}-BWMS.
	2	To check whether the HY^{TM}-BWMS ballast water management system can run stably after being started for 3 minutes and then detect the TRO of the inlet water and the ballast water treated at the sampling point.
	3	After the HY^{TM}-BWMS ballast water management system is stable for 3 minutes, collect the water sample of 1.2m^3 from the inlet water.
	4	After the HY^{TM}-BWMS ballast water management system is stable for 19 minutes, collect the water sample of 1.2m^3 from the inlet water.
	5	After the HY^{TM}-BWMS ballast water management system is stable for 35 minutes, collect the water sample of 1.2m^3 from the inlet water.
	8	Inject water into the ballast cabin
	9	Inject water into the control cabin
Unloading	1	Prepare the pipeline system for the seawater inlet pipe
	2	Start on the unloading treatment test of the first cycle
	3	To detect the TRO of the unloading discharged water at the sampling point and collect the water sample of 1.2m^3 ×3 from the unloading discharged water when the water is discharged from the ballast cabin for 3 minutes.

	4	To collect the water sample of 1.2m^3 ×3 from the unloading discharged water when the water is unloading discharged from the ballast cabin for 19 minutes.
	5	To collect the water sample of 1.2m^3 ×3 from the unloading discharged water when the water is unloading discharged from the ballast cabin for 35 minutes.
	6	To collect the water sample of 1.2m^3 from the discharged water when the water is discharged from the control cabin for 3minutes.
	7	To collect the water sample of 1.2m^3 from the discharged water when the water is discharged from the control cabin for 19 minutes.
	8	To collect the water sample of 1.2m^3 from the discharged water when the water is discharged from the control cabin for 35 minutes.
6		Clean all test tanks (disposal and water supply tank) and sampling vessel.

6. Sampling Design and Arrangement

6.1 Sample points for the test process

The process flow and sample points for ballasting are shown in Fig.6.1.

As you can see from the figure, the seawater flows through the sea chest and then into the pipeline system via the ballast pump when the water sampler of the pipeline will collect the water sample of the inlet water at point A, to confirm whether the inlet water conforms to the requirements of G8.

When ballasting, a part of inlet water flows through the Y typed filter and then into the HY^{TM}-BWMS ballast water management system via the pipelines for being treated and finally flows into the ballast cabin; the other part of inlet water will directly flow into the control cabin without being treated by the HY^{TM}-BWMS ballast water management system.

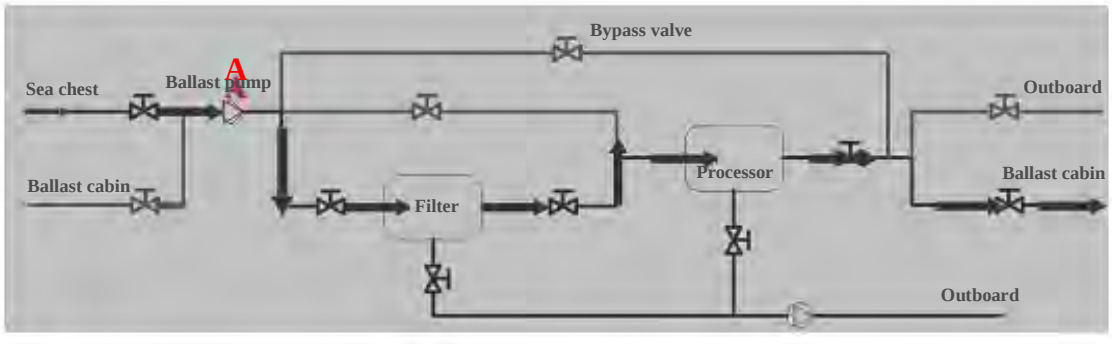


Fig. 6.1 The Technological Process of Test and Sampling Points When Ballasting

Point A is for sampling within the pipeline.

For the technological process of test and sampling points when unloading, see Fig.6.2.

It is observed from the figure that for discharge occurring once the 5-day storage expires, water from ballast compartment is once more pumped by ballast pump into the HY^{TM}-BWMS ballast water management system for treatment before it is directly discharged into the sea; While the water from the matched is not treated by the HY^{TM}-BWMS ballast water management system before it is directly discharged into the sea.

During unloading, the water sampler of pipelines will be used to collect the water sample from the water unloading discharged at point B, and to collect the water sample of the water discharged from the control cabin at point C.

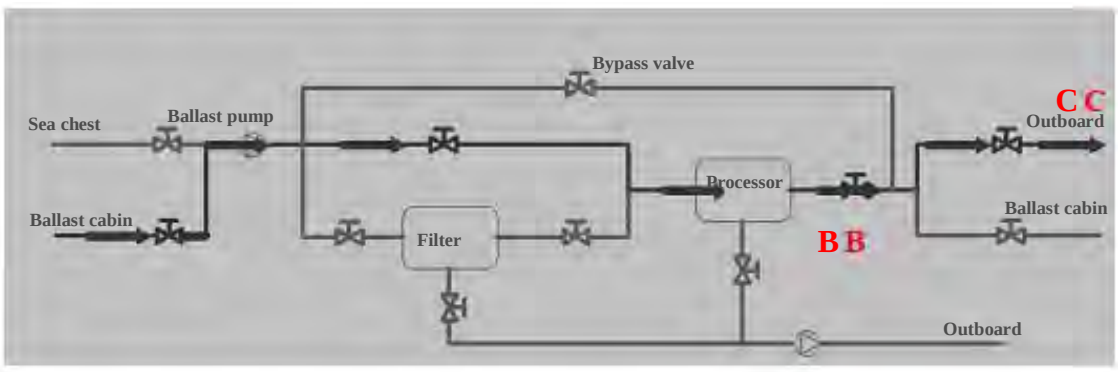


Fig. 6.2 The Technological Process of Test and Sampling Points When Unloading

Points B and C are for sampling within the pipeline.

6.2 Sampling equipment

As shown in Fig.3.1 and Fig.3.2, the whole HY^{TM}-BWMS ballast water management system is equipped with total three sampling points such as points A, B and C. When sampling at the three points, only the sampling devices within the pipeline are used as shown in Fig.3.3. All sampling devices are designed according to the sampling specification (clause 4.7, chapter 1, part 3, topic 2 of the article of association and regulations in California), and the port diameter will be calculated in the following formula: $\mathrm{Diso} = Dm\sqrt{\frac{Qiso}{Qm}}$

Here, Diso and Dm indicate respectively the aperture of sampling port and the inner diameter of sampled pipe; Qiso and Qm indicate respectively the velocity of flow when water pass through the 2 pipes.

Through calculating, the port diameter of the sampling devices is 63mm and the flow rate for sampling is 25.2m^3/h and it will take about 2.5 minutes to sample water sample of 1 m^3.

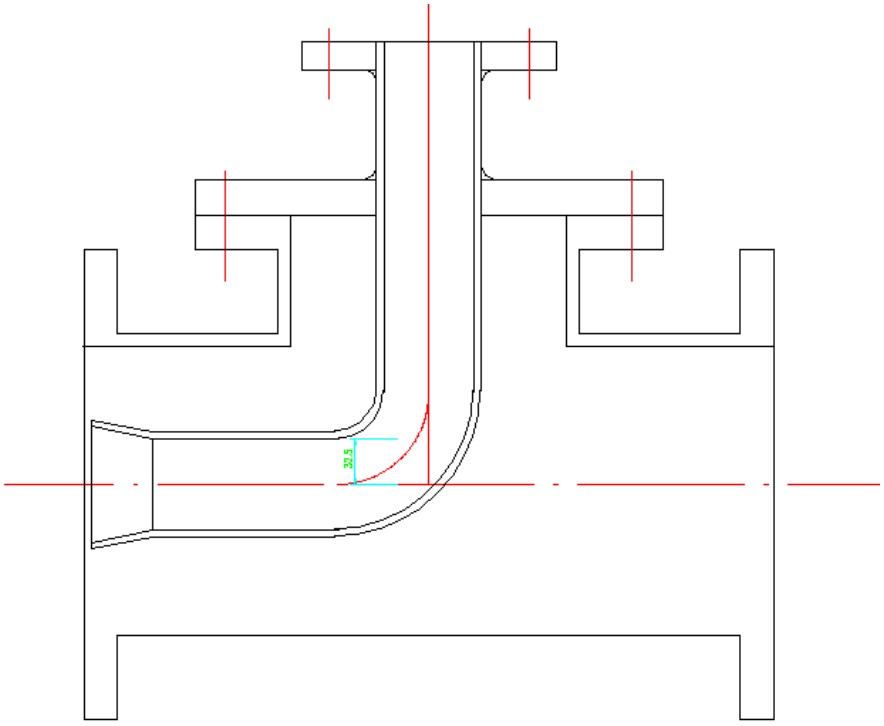


Fig. 6.3 Inside-pipe Sampling Device

As shown in Fig. 6.3, because the HY^{TM}-BWMS ballast water management system is installed in the engine room which is so extremely narrow that it is not convenient for sampling, the outlet end of the sampling devices is equipped with a flowmeter and a hose which is intended to draw the water to the appropriate location outside for sampling.

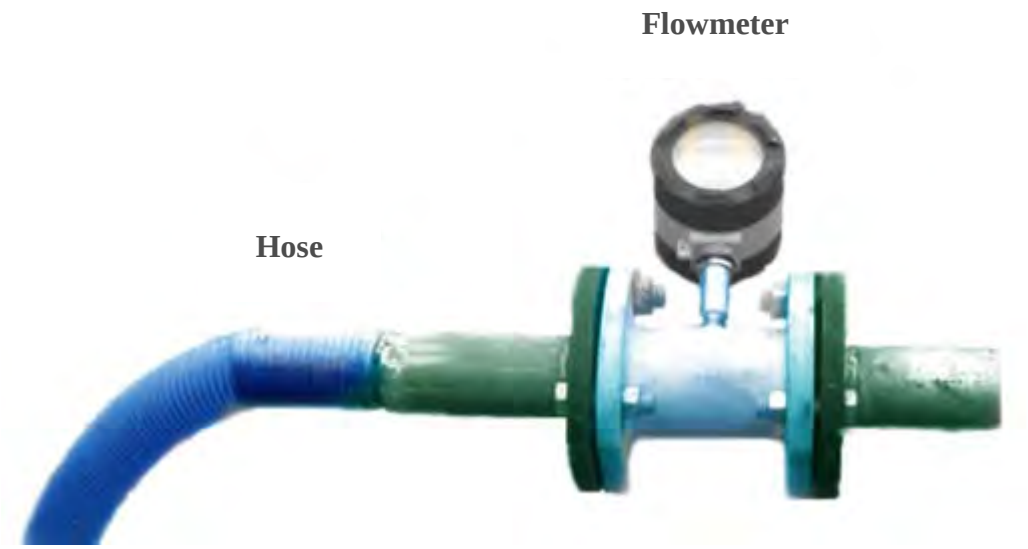


Fig. 6.4 Flowmeters and hose

6.3 Regulation of sample numbering

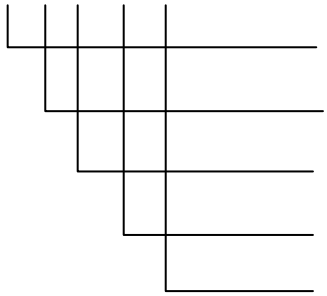
According to the requirements of G8, the document about the results of three consecutive effective test cycles (the ballast water treated is discharged according to the regulation of clause D-2) should be submitted. Total four test cycles will be carried out for this ship-based test and the total time span is six months. In the process of the whole test, samples with different times and different quantities and different test objectives shall be respectively and scientifically numbered to avoid the sample confusing and guarantee the authenticity and validity of the test data.

The implication presented by each letter or figure is specified in Table 4.1.

Category	Description
Test cycle No.	1,2,3,4,5
Category of gathered water sample	I: Inlet water for ballast T: Unloading water discharged C: Discharge water from the control cabin
Different sampling time	B: Initial stage; M: Intermediate stage E: Ending stage
Number of different samples at the same time	1,2,3
Analyze the water for different parameters	a: ≥50μm biology; b: 10～50μm biology; c: Microorganism; d: Water quality

Tag, numbering and style of test sample for ballast water treatment

S1×I-B×1 / a Description



Test cycle number 1, 2, 3, 4

Category for the water sample collected I: inlet water; T: unloading water discharged; C: discharge water from the control cabin;

Sampling time B: Initial stage, M: Intermediate stage, E: Ending stage

Number of different samples at the same sampling time: 1, 2, 3

Water quality analysis & Biology water a: >50μm; b: 10～50 μm; c: Heterotrophic bacteria; d: Water quality analysis

Remark: according to the requirements of G8 guidance, only one sample should be sampled for the inlet water for ballast and the unloading discharge water from the control cabin at the beginning, middle and end of the test while total three samples should be sampled for the discharge water discharged at the time period in question.

Example 1

The number of the sample sampled at the end of the second cycle of the ship-based test when the organic matter in the discharge water discharged is more than 50 ㎛: S2T-E3/a

Example 1

The number of the sample sampled at the middle of the first cycle of the ship-based test when the organic matter in the inlet water for ballast is 10~50 ㎛: S1I-M/b

6.4 Time, Location and Quantity of Sampling

The whole sampling process for this ship-based test will be conducted under the witness of the on-site surveyor who will seal the samples on site and indicate the sampling time on the seal, and the actual sampling time will also be recorded on the sampling records.

As shown in Fig. 6.5, according to the requirements of G8, the ship-based test will be equipped with total three sampling points, i.e. A, B and C for which the samples are sampled within the pipelines. The specific sampling purposes for each sampling point is described as follows:

Point A: take sample from ballast inflow water;

Point B: to take samples from the unloading water discharged;

Point C: take sample from discharged water in the control cabin;

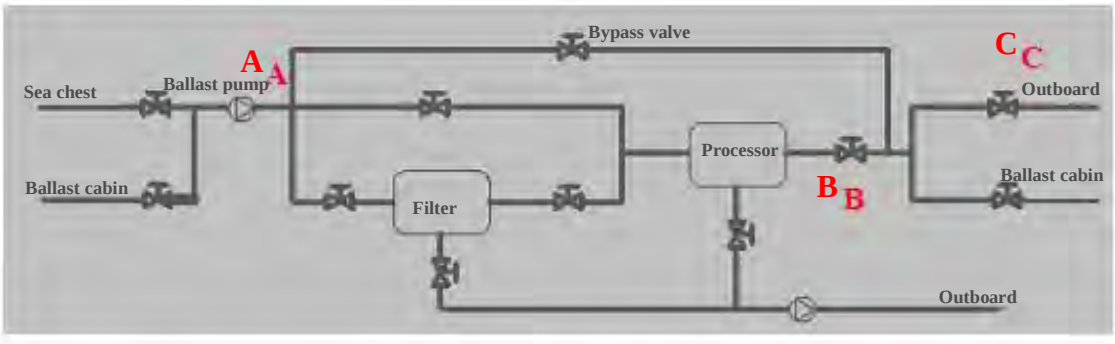


Fig. 6.5 Sampling point

During the ballast and unloading period, the time, location and quantity for each sampling are determined by different requirements of the test items. The sampling time, specification and quantity on different test stages are listed in Table 4.2.The actual sampling operation on board should be cosigned by the sampling personnel and the surveyor for witness.

Table 4.2 Time, Location and Quantity of Sampling in the Process of Test.

Category		Sampling time (start to time from the beginning of the test)	≥50μm organism	10～50μm organism	Microorganism	Sampling point	Sampling personnel	Witnessing surveyor
1	Ballast Inflow water	3~9 minutes	1 m3	1 L	500 mL	A		
		19~25 minutes	1 m3	1 L	500 mL			
		35~41 minutes	1 m3	1 L	500 mL			
3	Unloading Discharged water	3~9 minutes	1 m3 x 3	1 L x 3	500 mL x 3	B		
		19~25 minutes	1 m3 x 3	1 L x 3	500 mL x 3			
		35~41 minutes	1 m3 x 3	1 L x 3	500 mL x 3			
5	Control cabin Discharged water	3~9 minutes	1 m3	1 L	500 mL	C		
		19~25 minutes	1 m3	1 L	500 mL			
		35~41 minutes	1 m3	1 L	500 mL			

6.5 Data record by monitoring instrument and gauge during testing

In the process of test, the working parameters of the ballast water treatment device shall be recorded, for example, current, voltage, power consumption and flow. As shown in Table 4.3, the record of these parameters shall be conducted during the sampling period in the process of test. These parameters shall be recorded by the designated personnel in the Hengyuan Marine Equipment Co., Ltd, and shall be conducted in the presence of the surveyor.

Table 4.3 Data Record Sheet during Each Test Cycle Period

Test	Test cycle	Voltage	Current	Power	Average	Differential	Recorder	Witnessing	Time

Project		(V)	(A)	consumption (KW)	flow rate (m^3/h)	pressure and pressure at the input port and output port of equipment (MPa)		surveyor	
Treatment cabin	S1I-B1								
	S1I-B1								
	S1I-B1 - - -								
Control cabin	- -								
	-								
	- - -								

Table 4.4 Record Chart of the Location of the Ship and the Weather Conditions during Each Test Cycle

Test cycle \ Items		Water body (m^3)	Port	Longitude/Latitude	Climate	Winds and waves	Temperature (℃)	Water temperature (℃)	Date
1st cycle	Ballast								
	Unloading								
2nd cycle	Ballast								
	Unloading								
3rd cycle	Ballast								
	Unloading								
nth cycle	Ballast								
	Unloading								

Table 4.5 Records of the Cycles of Failed Test

Test cycle		Date Tested	Test results		Remarks
			Non-conformance to the standard D-2	Test failure	
1st cycle	Ballast				
	Unloading				
2nd cycle	Ballast				
	Unloading				
3rd cycle	Ballast				
	Unloading				
nth cycle	Ballast				
	Unloading				

7. Collection, Transfer and Detection of Samples

The sample test for this test will be undertaken by the First Institute of Oceanography, SOA and a special test room will be setup in the passenger cargo ship No. magnolia liliiflora for analyzing the samples. Since the office under the normal environment can be suitable for the conditions required by the test room, there are no requirements for the temperature, humidity and purification. After taking samples, the sample analysis can then be conducted in the test room (the following test will be deemed to be conducted in the test room, unless otherwise specified). All samples must be measured within six hours after sampling. The samples that cannot be finished within six hours must be cured and then taken back to the test room in Qingdao for reducing and then for test. The personnel from the First Institute of Oceanography, SOA should validate whether the seal sealed by the surveyor for witness is available on the samples when get the samples for analyzing. And meanwhile the personnel should mark and keep a record as well as indicate that in the report to be issued.

7.1 Test parameters

Based on G8 requirement, test the following parameters:

(1) Water quality: temperature (temperature), salinity (salinity), pH, dissolved oxygen (DO), turbidity (turbidity), dissolved organic carbon (DOC), particle organic carbon (POC), total suspended particulates (TSS).

(2) Organisms: Organism ≥ 50μm（mainly refer to zooplankter）, Organism ≥ 10~50μm（mainly refer to phytoplankton）

(3) Microorganism: Heterotrophic bateria, Escherichia coli, Enterococcus faecalis and Vibrio cholerae

7.2 Collecting, treating, testing and storage for sample

The water from each experimental cabin shall be drained into PE bucket that is prepared (attached with label properly) and washed properly one by one in advance. The sampling taking from the large plastic bucket shall be performed for water sample to be analyzed, respectively referring to:

7.2.1 Water quality

(1) Temperature, salinity: directly measure at the sampling mouth of water distribution cabin, or measure in the vessel by employing the water sampler.

(2) Turbidity: directly measure by the multi-parameter analyzer jointly with temperature and salinity (or measure by spectrophotometer in the laboratory for sampling).

(3) pH: the water sample is poured into 100ml flasket to perform the onsite testing, each sample has three parallel samples.

(4) DO: it is poured into special brown DO sample flasket and the fixing agent is added to perform the indoor testing on the site.。

(5) POC: the water sample is filtered by GF/F that is scorched (the filtering volume is determined based on the density of suspended matters and suspending biology), the sample on the filtering membrane is folded and packaged properly by the aluminum foil as well as numbered and stored in freezing under -20℃. When the long-distance transportation is within 12 hours, the sample must be stored in the dry ice or the freezer where the dry ice is placed as well as transported back to laboratory and put into the low-temperature freezer for

awaiting test.

(6) DOC and TSS: 2L water is sampled and filtered by GF/F glass fiber filtering membrane that is scorched with 450℃ and weighed (the filtering volume is determined based on the density of suspended matters and suspending biology), the sample on the filtering membrane is folded and packaged properly by the aluminum foil as well as numbered and packaged by the sealed plastic bag. The sample is transported back to the laboratory and baked for over 12 hours in 60℃ oven as well as weighed. The filtered water sample (DOC) is installed into the flasket via acid soaking and washing as well as transported back to the laboratory for testing.

7.2.2 Marine organisms

(1) For 50μm biology（mainly referring to zooplankter）, 1m^3 water sample is filtered by 50μm sieve at the sampling point of water distribution cabin, and the microscope is employed to directly perform the observation and appraise the counting. If the quantity of sample is too much, the activity condition of biology may be observed firstly under the microscope, the record should be performed properly and the medium dyed red is added as well as stored in freezing under -20°C. After unfreezing when returning to the laboratory, the counting is appraised in accordance with coloring degree.

(2) 10～50μm biology is filtered by 10μm sieve at the sampling point of water distribution cabin (1L sampling for inflowing water; 10L sampling for treated water and contrasted water), the inverted microscope is employed firstly to directly observe the status of living organism for cell, and then formaldehyde (2% for final concentration）or Lugol iodine solution （1% for final concentration）is employed for fixing and transported back to laboratory for appraisal and counting. The sub-sample shall be taken from each sample for three times for appraisal and counting.

The fluorimeter is employed to test the fluorescence of living organism for phytoplankton, or the chlorophyll is leached or PAMfluorimeter is employed to test the photosynthesis activity.

7.2.3 Microorganism testing

The sterile gathering must be taken for microorganism sample, and the sample must be subject to high-temperature sterilization. Take 500ml by 500ml glass flasket with high-pressure sterilization and respectively perform the measuring and taking according to the water sample quantity required by various floras after returning to the laboratory. Within two hours after sampling, implement the inoculated culturing. If the inoculated culturing can’t be completed within two hours, the sample should be put into the refrigerator or ice box for temporary storage, and the storage period can’t exceed 24 hours.

The sampling shall be performed at the sampling point and respectively put into the culture medium for various s according to the operating method for various floras, the detailed operation shall be conducted in accordance with the ocean monitoring specification.

7.2.4 Control on sample gathering, transferring and testing time

The on-site sampling time should be limited to less than two hours, the time from sampling on site to the test in test room should be limited to about half an hour; when the samples arrived at the test room, the test should be conducted immediately and the test time should be limited to less than three hours. Therefore total time will be limited to less than six hours.

7.3 Testing method

7.3.1 Water quality parameters

(1) Temperature: direct measurement by the inductive probe for temperature by multiparameter water quality meter.

(2) Salinity: direct measurement by the inductive probe for temperature by multiparameter water quality meter.

(3) pH: Potentiometry method

(4) Turbidity: Direct measurement by the multiparameter turbidity probe;

(5) Dissolved oxygen (DO): iodometry

(6) Total Suspended Solids (TSS): Weight Method

(7) Dissolved Organic Carbon (DOC): High-temperature combustion method

(8) Particle Organic Carbon (POC): High-temperature combustion method

7.3.2 Biological parameters

(1) Biology ≥50μm: Employ the little sieve made by 50μm silk sieve to filter a certain amount of water body or vertically drag and concentrate. While being analyzed, perform the appraisal and counting wholly, or the sample spliter is employed to divide it into equal volume, and take equal sample for appraisal and counting. and then convert it as individual number for 1L water. (Pc./m^3).

$$C_B = \frac{N_B}{V}$$

Where:

CB——individual density of zooplankton in the seawater with unit volume, unit: (ind/m^3);

NB——number of whole sieve, unit: Pc. (ind or cells);

V——Quantity of water filtering unit: (m^3).

(2) Biology ≥50μm: Employ the little sieve made by 10μm silk sieve to filter 10L water body. While being analyzed, demarcate it up to certain volume based on the cell concentration, and then, take the uniform sample into the counting plate (frame) for appraisal and counting. convert it as number for 1L water cell. (Pc./L or cells/L). The computation formula is as follows:

$$C = \frac{n \cdot V_1}{V_2 \cdot V_n}$$

Where:

C——Amount of specimen in the seawater with unit volume, unit: number of cell in 1L water; (cells/L);

n——Number for sampling and counting, unit: Pc. (cells);

V1——Volume after concentration of water sample, unit: ml (ml);

V2——Quantity of water sample filtered by the little sieve, unit: L (L);

Vn——Volume for sampling and counting, unit: ml (ml).

(3) Heterotrophic bacteria: Panel technology method

Principle: The plate counting method means that the single heterotrophic bacteria may form a visible daughter-cell population (bacterial colony) via cultivation for certain period on the basis that the single heterotrophic bacteria locates on the panel culture medium, namely, a bacterial colony represents a bacterial cell, and the quantity of heterotrophic bacteria may be known via calculating the quantity of bacterial colony. The counting key is that the heterotrophic bacteria in the sample must be dispersed as single cell as much as possible and prepared as the uniform diluent with different concentration, and a certain amount of diluent is uniformly inoculated onto the petri dish filled with solid medium.

Method: Add 1ml Twain solution according to 100ml water sample, fully mix it uniformly so as to ensure that the heterotrophic bacteria in the sample disperses and presents the single cell. The aseptic manipulation method is applied to suck up 1ml water sample and inject it into 9ml test tube to sterilize the previous seawater as well as continuously dilute it up to required dilution by adopting the same method, three parallel samples are required for each kind of dilution. Take 0.1ml diluted water sample and inoculate it onto the culture dish filled with solid medium (2216E), uniformly daub the bacterium solution with sterilized glass rod. Put the nurture dish into the incubation box with 25℃ constant temperature for 7-day cultivation, take it and count the quantity of bacterial colony

(4) Vibrio cholerae: panel technology method

The total of vibrio is one of important parameters to reflect the pollution degree of pathogenic microorganism for water body, the TCBS panel selective cultivation medium is adopted to test the total of vibrio. After sample inoculating, the sample shall be cultivated under appropriate temperature to count the bacterial colony with vibrio feature and perform further appraisal and conformation.

Method: The aseptic manipulation method is applied to inoculate the water sample with three kinds of different dilution (10-1 and 10-2) into the test tube of BTB cultivation solution by applying ‘ MPN’ method and cultivate for 18 hours under 37°C, separate the bacterial solution in the positive tube on TCBS panel by marking the line and put the panel into the incubator under 37°C for 18-hour cultivation, inoculate the appeared green, blue-green and yellow culture onto the CPA bevel, the separated bacterial strain shall be subject to gram coloring, oxidase, moveability and 0/129 vibrio rope sensitivity test firstly. The bacterial strain conforming to the vibrio feature shall be calculated on the basis of pipe quantity for originated “MPN” and checked in “MPN” table.

(5) Coliform bacteria testing: filtering membrane method

Inject the water sample into the filter that has been sterilized and placed with micropore filtration membrane. Subject to suction filtration, the heterotrophic bacteria is withheld onto the filtration membrane, and then, the filtration membrane is tightly pasted on the appropriate selective cultivated medium for cultivating. After certain period of time, count and appraise the coliform bacterial colony growing on the filtration membrane, convert as the coliform bacterial colonyincluded in the water sample per litre.

Method: Inject 100ml sample into the filter that has been sterilized and placed with micropore filtration membrane (cellulose acetate filtration membrane with 0.2μm in aperture). Subject to suction filtration, the

heterotrophic bacteria is withheld onto the filtration membrane, and then, the filtration membrane is tightly pasted on the appropriate selective cultivated medium (M-TEC) for cultivating, invert the panel and put it into 37℃ incubator for 0.5-hour cultivating and then move into 44℃ incubator for 18~24 hour cultivating Count and appraise the coliform bacterial colony growing on the filtration membrane, count the coliform bacterial colonyincluded in the water sample per litre.

(6) Enterococcus

PSE selective cultivated medium with agar panel is adopted for testing the total of enterococcus. After the sample is inoculated, cultivate in 37℃ incubator for certain period of time, calculate the bacterial colony with enterococcus characteristic and conduct the further appraisal for separation and purification.

The method is same as that of escherichia coli

8. Quality control

8.1 Quality system

The provisions of the sample test quality assurance program for ship-based test for the HY^{TM}-BWMS 200t ship ballast water will be followed.

Table 8.1 Test Parameter, Test Methods, Sensitivity and Work Basis.

Parameters	Unit	MDL	Analysis method	Sensitivity	Basis
Temperature	℃	NA	Probe of multi-parameter analyzer	0.1℃	Ocean survey specification
Salinity	PSU	1.0	Probe of multi-parameter analyzer	0.5 PSU	Ocean survey specification
pH	pH	0.0	pH meter method	0.01 pH	Ocean Survey Specification
Dissolved Oxygen	mg/L	0.1 0.2	Iodometry	0.05 mg/L	Ocean Survey Specification Ocean Survey Specification
Turbidity	NTU	0.1	Optical spectroscopy or turbidity probe for multi-parameter analyzer	0.1 NTU	Ocean survey specification
DOC (Dissolved Organic Carbon)	mg/L	0.36	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
POC (Partical Organic Carbon)	mg/L	0.1	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
Total Suspended Solid	mg/L	1.0	Weight method	0.1mg/L	Ocean survey specification
Organisms ≥50 ㎛	ind./m3	1.0	Filtering and concentrating by 50μm screen, appraisal and counting by inverted microscope	ind./m^3	Ocean survey specification
Organisms ≥10~50 ㎛	ind./mL	1.0	Filtering and concentrating by 10μm screen, appraisal and counting by inverted microscope	cell/mL	Hallegraeff. Anderson and Cambella
Escherichia coli	CFU/100mL	1.0	Filtering membrane method	CFU/100mL	Ocean Survey Specification
Intestinal Enterococci	CFU/100mL	1.0	Fecal *Streptococcus* and *Enterococcus* group Filtering membrane method	CFU/100mL	Standard Method 9230 orMM-FS-CNJ-0351（Inspection method for enterobacteria of exported

					commodities ）or ISO4833-2003
Vibrio cholera (Serotype O1 and O139)	CFU/100 mL	1.0	Plate method	CFU/100mL	Ocean Survey Specification

8.2 Equipment and instruments

No.	Description	Specification	Scope and precision	Place of production
1	Plankton sieve	25cm in diameter of sieve opening	Aperture 50μm	Self-made, the silk screen originates from USA--USA
2	Plankton sieve	25cm in diameter of sieve opening	Aperture 50μm	Self-made, the silk screen originates from USA--USA
3	Precise acidity meter	PHS-3C	0～14 0.01pH	Shanghai China
4	Electronic scale	ME614S	0～610g 0.1mg	Sartorius, German
5	Total organic carbon analyzer	TOC-VCPH	0.028mg/l	Nikon, Japan
6	Fluorescence microscope	EC501	1000×	Nikon, Japan
7	Inverted fluorescence microscope	TE2000-U	400×	Nikon, Japan
8	Inverted microscope	TS100	400×	Nikon, Japan
9	Anatomical lens		200×	OPTON, West Germany
10	Microcomputer counter	MCC1-1	100×3 10 60 100	Qingdao, China
11	Leaching device	250ml, 500ml		Qingdao, China
12	Multi-parameter water quality meter	YSI6600		USA
13	Multi-parameter water quality meter	HydroLab H5		USA

8.3 Quality guarantee measures

8.3.1 Quality guarantee measures for onsite sampling

All samples shall be collected at the testing site. The collected water sample shall be subpackaged into the sample bottles for each testing item, and each sample bottle shall all be pasted with label and identification. In order to prevent and reduce the contamination, the sample bottles shall be washed by hydrochloric acid (except for PH) in advance and then washed in the pure water. Before sampling, the bottles shall be washed twice by the onsite seawater sample. The microorganism sample bottle shall be subjected to the autoclaved sterilization in advance. Each microorganism medium shall be prepared in the laboratory in advance and taken to the site for disinfection.

The microorganism exceeding 50μm shall be filtered and concentrated on site by the mesh made from 50μm sieve silk and then put into the sample bottles. The microorganism with a size of 10μm~ 50μm shall be shall be filtered and concentrated on site by the mesh with made from 10μm sieve silk and then put into the sample bottle.

5.2.3.2 Quality guarantee measures of sample saving and transportation.

The anti-pollution measures shall be taken into the process of sample filtration and subpackaging. POC, DOC and microorganism sample must be operated with gloves. The sample which could not be analyzed on site shall be saved by frozen (chlorophyll a, dissolved organic carbon and Particulate Organic Carbon) after pretreatment and put in the dry ice during the transportationThe plankton shall be properly sealed and then hauled to the laboratory.

8.3.2 Quality control

8.3.2.1Quality control on analytical test

- The instruments used for various tests all shall meet the project requirements.
- Before the sample is tested, at first, check the sample, requirements: the inside and outside marking of the sample shall be in accordance with the on-site sampling record and be complete.
- After the sample analysis, the analytical and detecting instruments must be kept under normal status.
- When there is unusual for the analysis results and detecting analysis, the reason shall be timely analyzed to conduct the reasonable analysis and conclusion, if necessary, all the analysis and detection shall be repeated again.
- Except for the postgraduates, the personnel for analysis and test shall hold the on-post certificate for marine environmental monitoring Although the postgraduates have the on-post certificate, but they shall be subjected to the on -job training which is professionally tested and training guidance before the project is tested.

8.3.2.2 Quality control for testing process.

Carry out the technical disclosure to all testing personnel, clear and definite responsibilities and quality responsibilities for each job

After the instruments and equipment enter into the site, check whether the instruments and equipment are normal; After the instrument installation is in position, check, correct/ calibrate it again and keep records;

The operator shall operate the instruments according to the satisfactory specification, standard stipulations with valid version;

After the observation is completed, check whether the instrument is in the normal condition;

If the testing is interrupted due to the fault or the operation is required to be changed, the situation shall be reported to related leader, and after obtaining the approval, the change could be implemented.

8.3.2.3 Control of checkout equipment

All used instruments and equipment shall be authenticated by the national statutory authority and guaranteed to be operated with the effective period. Before self-inspection instruments are put into operation, each professional staff shall implement the comparing and testing calibration

8.3.2.4 Filling of original record

1) The original record is the factual record of the testing result and is not allowed to modify or delete, and the original sampling record shall be signed after being witnessed by surveyor from Classification Society

2) The format of original record is uniform and couldn't be filled by pencil (unless otherwise there is stipulation), and the r contents shall be filled completely with the signature by the tester and corrector

3) The confirmation of significant digit for test data and data processing must be strictly implemented according to the stipulation of GB/T-12763-2008 Standard and *Ocean Monitoring Specification*

9. Emergency Plan

Dispose the unexpected cases prior to and during the test according to emergency plan. Treatment principle in an emergency is that personnel security comes first and the protection of property and environment follows so as to minimize the losses as much as possible. Record for any case presenting in test process and analyze the causes seriously to get the solutions. Solutions to specific problems occurred in the test refer to Table 9.1.

Table 9.1 Solutions under emergency condition

Cases	Response solutions
1. Power failure of main power source	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency condition. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
2. Malfunction of ballast pump	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
4. Malfunction of UV module	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
6. Personnel injury	1. Send injuries to the nearest hospital timely. 2. Assign new staffs.

10. Test Basis

1) Approval guideline of ballast water management system G8 (MEPC.174 (58) Decision)

2) Sub Committee on Bulk Liquids and Gases IMO 15th session Agenda item 5. 12/2010.Development of guidelines and other documents for uniform implementation of the 2004 BWM convention, Additional guidance on indicative analysis

3) WMS Test Items & Test Standard for Type Approval of UV Disinfection System) ， Land-Based Test & Shipboard Test

4) The Fifth Part of Specifications for Oceanographic Survey, Ocean Chemical Investigation (GB/T12763.5-2007)

5) The Sixth Part of Specifications for Oceanographic Survey, Marine Organism Investigation (GB/T12763.6-2007)

6) The Fourth Part of Marine Pollution Monitoring Specification, Water Quality Monitoring and Analysis (GB17378.4-2007)

7) The Seventh Part of Marine Pollution Monitoring Specification, Offshore Pollution Ecological Investigation and Biological Monitoring (GB17378.7-2007)

8) Manual on harmful marine microalgae, G.M Hallegraeff, D.M. Anderson and A.D. Cambella. Intergovernmental oceanographic commission. Manuals and Guides 33. 1995.Paris.